# Financial Analysis of BOT Projects with Two Phases Market Risks

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Abstract

Public-Private-Partner (PPP) projects may relief the financial burden of host agent, which make PPP becomes a populous scheme in infrastructure projects around the world. However, infrastructure projects are with project nature of huge investment amount and long construction period, which might result in financial infeasible for infrastructure projects. Thus, it is very important to conduct an elaborate model for financial analysis of PPP projects. We consider inflation rates and interest rates for market risk of PPP projects; and construction cost and construction duration for project risk of PPP projects in this study. In general practice, arithmetic average approaches on interest rates and inflation rates are widely used in the financial analysis of PPP projects. We use a time series model to predict the expected value and variance of inflation rates and interest rates for the PPP projects in construction period and arithmetic average approaches for those in operation period. A comparison on the results of these two methods is conducted. Data of interest rates and inflation rates in Taiwan are from January, 1991 to December, 2001. It is a 216 data set. The results show that the arithmetic average approach can't provide good estimate for the interest rate and inflation rate in the construction stage, which will underestimate the market risk of the project. Eventually, a Monte Carlo analysis is conducted for the valuation of value at risk (VaR) of PPP projects. An empirical study on the dormitory project in National United University is conduced to demonstrate the effects of market risk on PPP projects. The results show that cost overrun, time delay and high fluctuation in inflation rate are all seriously deteriorated the financial feasibility of the project.

Keywords: Public-Private-Partner, time series, VaR

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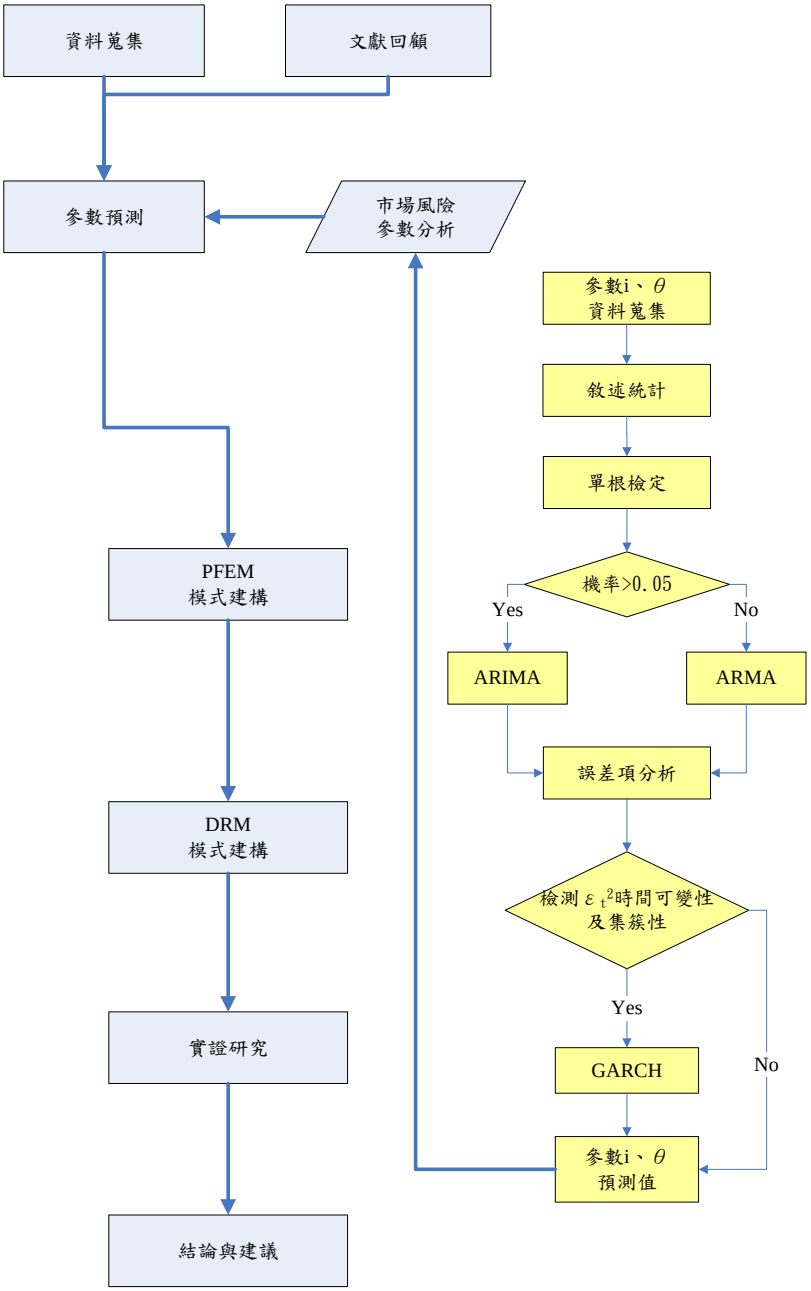
## 1. Introduction

Financial Risk Management has generally focused on short run risks rather than long run risks and arguably this is an important component of the current financial crisis. Investors concerned about long run risks can hedge. Such hedging will affect asset prices and can be tested directly with volatility models. Some evidence is found for several types of hedge portfolios including volatility, long bonds, term spread, credit spread and gold. Theoretical time series predictions on the relationships among volatility, returns, and skewness for priced risk factors. Market returns resemble these predictions; however, size, book-to-market, and momentum factor returns show alternative behavior, leading us to conclude these factors are not priced risks. We attempt to investigate the short term and long term risk in project financing as shown in the following framework.



## 2. Modeling

**ARMA model**

ARMA is model which consists of Auto-regressive (AR) model, Moving-Average（MA）model and Auto-regressive Moving-Average (ARMA) model.

AR(p) : Auto regression model with order p.

$y_t = \phi_1 y_{t-1} + ... + \phi_P y_{t-p} + \varepsilon_t$ where $\{\varepsilon_t\}$ is error term with $E(\varepsilon_t) = 0$ ，$Var(\varepsilon_t) = \sigma_\varepsilon^2 > 0$.

$\phi(B) y_t = y_{t-k}$ with $\phi(B) = 1 - \phi_1 B + ... + \phi_p B^p$

MA(q)：Moving average model with order q.

If a time series $\{y_t\}$ satisfies $y_t = \varepsilon_t - \theta_1 \varepsilon_{t-1} - ... - \theta_q \varepsilon_{t-p}$, is called MA(q). $y_t = \theta(B)\varepsilon_t$ 。

ARMA(p,q)：In case that a time series $\{y_t\}$ satisfies

$$y_t = \phi_1 y_{t-1} + ... + \phi_P y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - ... - \theta_q \varepsilon_{t-q}$$

A time series $\{y_t\}$ follows order (p,q). Or $\phi(B) y_t = \theta(B)\varepsilon_t$.

## 3. Empirical Study

The case of university dormitory of National United University (NUU) at Taiwan is to illustrate as an empirical study of this paper. It is a BOT project of dormitory in National United University. The input parameters and results are shown as follow. Data of interest rates and inflation rates in Taiwan are from January, 1991 to December, 2001. It is a 216 data set.

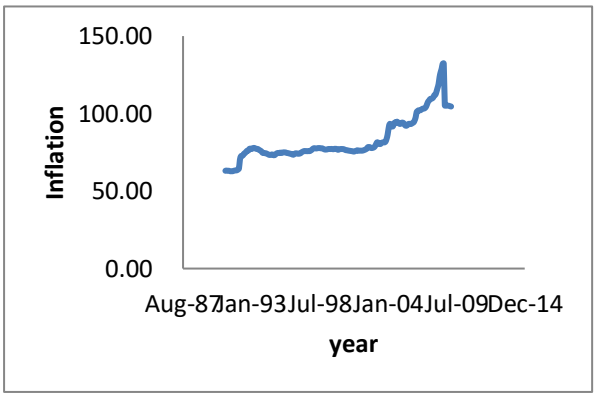



Figure 1 Price inflation rates in Taiwan are from January, 1991 to December, 2001

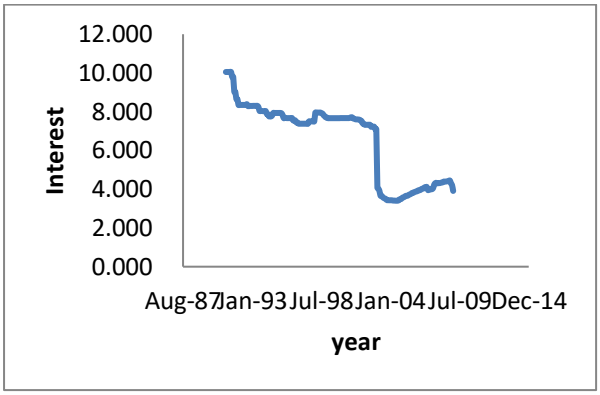



Figure 2 Interest rates in Taiwan are from January, 1991 to December, 2001

Table 1 Prediction the price inflation by ARMA model

| ARMA | | year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | value | | | standard deviation | |
| | ARMA | AIC | SBC | forecast | real | error | Dynamic | Static |
| difference | (1,0) | 6.093762 | 6.185056 | 117.42 | 124.25 | -5.4958% | 2.236336 | 2.101272 |
| | (0,1) | 5.664120 | 5.758527 | 116.70 | | -6.0770% | 2.189322 | 1.896280 |
| | (1,1) | 5.472894 | 5.609835 | 118.78 | | -4.4063% | 2.188713 | 1.736048 |
| ratio | (1,0) | -3.143753 | -3.049347 | 135.12 | | 8.7491% | 0.2119 | 0.2242 |
| | (0,1) | -2.893400 | -2.796826 | 114.34 | | -7.9751% | 0.2296 | 0.2242 |
| | (1,1) | -3.010784 | -2.869174 | 136.31 | | 9.7093% | 0.2120 | 0.2097 |
| log | (1,0) | -4.905422 | -4.811015 | 113.85 | | -8.3731% | 0.1365 | 0.1350 |
| | (0,1) | -4.671637 | -4.575064 | 114.21 | | -8.0835% | 0.1472 | 0.1437 |
| | (1,1) | -4.772557 | -4.630947 | 113.81 | | -8.4019% | 0.1365 | 0.1350 |

Table 2 Prediction the price inflation by ARCH model

| ARCH | | year | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | value | | | |
| | ARMA | AIC | SBS | forecast | real | error | standard deviation |
| difference | (1,0) | 6.109605 | 6.337840 | 117.63 | 124.25 | -5.3249% | 4.7318 |
| | (0,1) | 6.201312 | 6.437328 | 117.45 | | -5.4722% | 3.4186 |
| | (1,1) | 5.692819 | 5.966700 | 119.19 | | -4.0734% | 4.0526 |
| ratio | (1,0) | -3.090911 | -2.854894 | 137.89 | | 10.9791% | 0.0615 |
| | (0,1) | -2.997379 | -2.755945 | 113.22 | | -8.8793% | 0.0563 |
| | (1,1) | -2.681115 | -2.397895 | 122.68 | | -1.2611% | 0.0557 |
| log | (1,0) | -4.767712 | -4.531696 | 113.51 | | -8.6449% | 0.0237 |
| | (0,1) | -4.683854 | -4.442420 | 113.45 | | -8.6888% | 0.0210 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1,1) | -4.728993 | -4.445773 | 113.32 | | -8.7999% | 0.0253 |

Table 3 Average and standard deviation of interest rates

| | Interest | |
|---|---|---|
| | average | standard deviation |
| 2years | 4.26 | 0.1630 |
| 5years | 3.93 | 0.3415 |
| 10years | 5.35 | 1.8161 |
| 15years | 6.13 | 1.8580 |
| 18years | 6.56 | 1.9719 |

Table 4 Prediction the interest rate by ARMA model

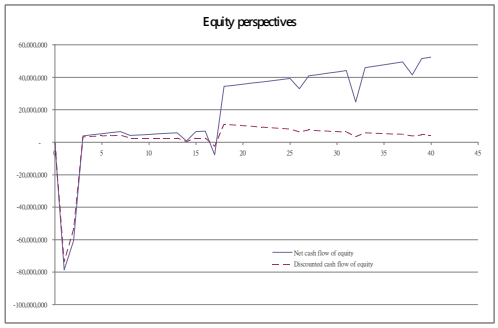
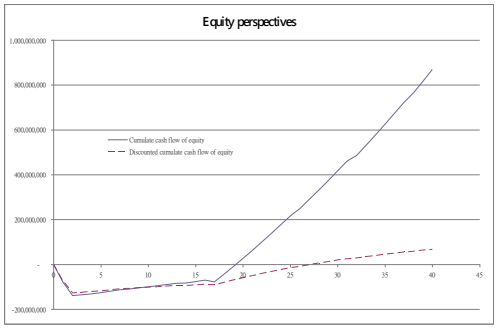
| ARMA | | year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | value | | | standard deviation | |
| | ARMA | AIC | SBS | forecast | real | error | Dynamic | Static |
| difference | (1,0) | 2.926869 | 3.021276 | 3.878 | 4.367 | -11.1887% | 0.9574 | 0.9566 |
| | (0,1) | 2.914684 | 3.011258 | 3.835 | | -12.1832% | 0.9583 | 0.9576 |
| | (1,1) | 3.052603 | 3.194213 | 3.946 | | -9.6362% | 0.9566 | 0.9547 |
| ratio | (1,0) | -0.981565 | -0.887158 | 4.595 | | 5.2151% | 0.3619 | 0.3600 |
| | (0,1) | -1.037816 | -0.941243 | 4.032 | | -7.6729% | 0.3590 | 0.3565 |
| | (1,1) | -0.867420 | -0.725810 | 3.213 | | -26.4143% | 0.3616 | 0.3583 |
| log | (1,0) | -2.044364 | -1.949957 | 3.974 | | -9.0077% | 0.2765 | 0.2760 |
| | (0,1) | -2.110531 | -2.013957 | 3.969 | | -9.1055% | 0.2733 | 0.2726 |
| | (1,1) | -1.921904 | -1.780294 | 4.026 | | -7.7977% | 0.2763 | 0.2753 |

Table 5 Prediction the interest rate by ARCH model

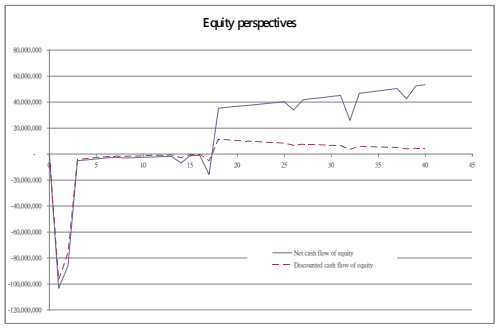
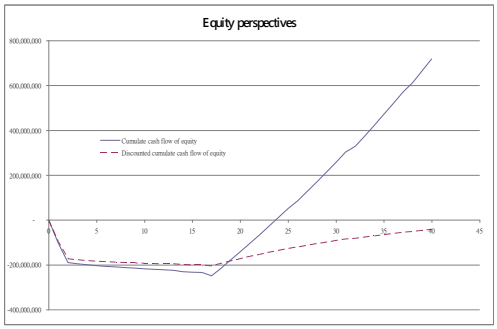
| ARCH | | year | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | value | | | |
| | ARMA | AIC | SBS | forecast | real | error | standard deviation |
| difference | (1,0) | 2.877567 | 3.113583 | 3.937 | 4.367 | -9.8487% | 0.7364 |
| | (0,1) | 2.990785 | 3.232219 | 3.935 | | -9.8818% | 0.6972 |
| | (1,1) | 2.800916 | 3.084136 | 4.002 | | -8.3559% | 0.6804 |
| ratio | (1,0) | -1.389957 | -1.153940 | 4.372 | | 0.1134% | 0.1059 |
| | (0,1) | -1.205296 | -0.963862 | 4.156 | | -4.8259% | 0.0562 |
| | (1,1) | -0.734617 | -0.451397 | 3.983 | | -8.7891% | 0.1059 |
| log | (1,0) | -2.114395 | -1.878378 | 4.113 | | -5.8203% | 0.0529 |
| | (0,1) | -2.054040 | -1.812606 | 4.029 | | -7.7313% | 0.0546 |
| | (1,1) | -2.070831 | -1.787611 | 4.028 | | -7.7725% | 0.0619 |

**Scenario Analysis**

Optimal case

| | Annual cash flow | Discounted accumulate cash flow |
|---|---|---|
| Optimal case |  Figure3 Annual cash flow |  Figure 4 Discounted accumulate cash flow |
| | NPV=67,778,199、IRR=8.68%、PI=1.53 | |

Pessimistic case

| | Annual cash flow | Discounted accumulate cash flow |
|---|---|---|
| Pessimistic case |  Figure5 Annual cash flow |  Figure 6 Discounted accumulate cash flow |
| | NPV=-42,024,737、IRR=5.50%、PI=0.77 | |

**Risk Analysis**

Table 6 the results of scenario analysis

| | NPV | Variation | IRR | Variation | PI | Variation |
|---|---|---|---|---|---|---|
| Base case | 48,486,383 | 0% | 7.96% | 0% | 1.36 | 0% |
| Optimal case | 67,778,199 | 39.79% | 8.68% | 9.04% | 1.53 | 13.11% |
| Pessimistic Case | -42,024,737 | -186.67% | 5.50% | -30.85% | 0.77 | -44.12% |

## 4. Conclusion

Market risk is considered as the volatility of inflation rate and interest rate in this study. We find that the interest rate and inflation rate are time series. It implies that it is unwise to use the arithmetic average to predict the short term risk. Especially, in the time with high fluctuation in market risk, a more dedicated model to predict the market risk is necessary.

In general practice, it is to adopt interest rate = 5% in project financial analysis. However, this value is less than average value of past 18 years, which is 6.56%. We find the average interest rate is 4.257% in 2 years, 3.99% in 5 years, 5.32% in 10 years, 6.13% in 15 years, and 6.563% in 18 years. It is a tough decision to determine the interest rate in project financial analysis.

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